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ABSTRACT

Engineering schools have been interacting, more and more, with society in a very intensive way in order to deal with its necessities, integrating them in these courses and, as a consequence, preparing professionals with an adequate profile. This paper shows the author's vision about the interactions between market and communities, and which are the actions to be taken as change agents in the academic world to achieve flexibility and engagement for excellence. This work also shows the author's vision about how to prepare an entrepreneur engineer and how the industrial activities will evolve in Brazil with these new structures. The old paradigm, "teaching," is now confronted with a new one, "learning," which requires that a new dynamic interaction with teachers, students, school, work market and society be implemented. Finally, the paper shows what FEI (Faculdade de Engenharia Industrial) is doing to deal with these challenges, and some questions are put forward for reflection and debates, which are relevant for all that are agents of development for the new engineering professionals. (ASK)

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ACTIONS FOR A NEW INDUSTRIAL ENGINEERING CURRICULUM BASED ON A CHANGING SOCIETY

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Abstract *- Engineering Schools have been interacting, more and more, with society in a very intensive way, in order to deal with its necessities, integrating them in these courses and, as a consequence, preparing professionals with an adequate profile. This paper shows our vision about the interactions between market and communities, and which are the actions to be taken as change agents in the academic world, to achieve flexibility and engagement for excellence. This work shows our vision about how to prepare an entrepreneur engineer and how the industrial activities will evolve in this country with these new structures. The old paradigm, "teaching", is now confronted with a new one, which is "learning", which requires that a new dynamic interaction with teachers, students, school, work market and society be implemented. At last, we show what FEI is doing to deal with these challenges and we also put forward some questions for reflection and debates, which, in our opinion, are relevant for all that are agents of development for the new engineering professionals.*

Introduction

The performance or the engineer's training can be classified in three different groups, that is, a researcher, to develop new concepts and new technologies, a planner, to design new products and new processes, and finally a systemic, who transforms these ideas in reality.

Professor Ruy Aguiar da Silva Leme [1] alerted in 1958: "We dedicate the largest part of the time of our school programs to train student in the execution of projects of buildings, facilities and equipment. We neglect the problems related to building and production. We make the mistake of judging that the student who is well prepared for design, can carry out efficiently the tasks related to production. We forget that if the Brazilian industry can, and should take advantage of foreign projects, that can be imported with payment of *royalties*, it can never import organization techniques or rationalization. The result is that, most of the time, engineers have a large and useless theoretical knowledge, inadequate for production problems, ignoring that the solutions of these problems present an immense work field, as noble intellectually as the execution of projects. This professional, thinking that he cannot do "Engineering" in factory, abandons, as soon as he can, the industry, seeking a post to work in projects, thinking that this will be better for him. And the worst of all is that all failures work against the engineer, or engineering as a whole, so that a lot of companies judge dispensable or even harmful their inclusion in their factories."

If we look at the world managerial scenery today, we can conclude that Brazilian companies should work inserted in a global economy and market. However, in this process, for their own economic and technological structures, they should concentrate their activities basically on manufacture and on product supply and services. The formation of strong partnerships and joint ventures should also be accelerated.

Paradoxically, we have to follow a minimum curriculum, without considering what kind of performance the engineers that we graduate will have. Besides this, the very professional regulation considers that the diploma for his professional practice is enough in one's lifelong career, in spite of having been elaborated many years ago, and far away for reality.

On the other hand, we should have a clear vision of what it represents to the student, and the market, in which he will act in the future. Although there is a lot of controversy about what it should be, we are absolutely convicted that our true customer is society and that the student should be faced as raw material that we have to refine, to transform him in a product of high quality, desired and indispensable for the customer. This observation may sound irrelevant, but it is fundamental for any evolution attempt, because it will give us the precise direction to be followed.

It is in this scenario, we believe, it may begin any attempt of definition of the engineer's profile, and consequently reshape his formation. It is based on these premises that we developed this work.

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The engineers usefulness in the new economical structures

2.

The first question that is put is that if the managerial structures are developing continually, and faster than ever, shouldn't the activities developed by the engineers in this context also change? Obviously yes, but wouldn't we be thinking in the same way we did thirty years ago?

Taking the global companies as a reference, we can notice that they produce more, and better, with less people, gathering products and talents of any place to sell away things to the whole planet. In this globalized economy, the traditional employment doesn't exist anymore. Unemployment is structural, and is generated by the combination of new technologies and costs reduction, to make companies more competitive. However, job opportunities are growing for those who are prepared to face the challenge of changes.

As it was previously mentioned, inside a globalized structure, companies in Brazil will concentrate their activities, especially, in production and supply. That is to say, that Brazil should participate in this process as a manufacturer: this fact should be considered in the definition of the engineer's profile, when possibilities in the labor market are taken into considerations. Not that other activities for engineers should be despised, but this is the profile that will offer more opportunities.

From this we derive that the engineers' activities will be mainly focused on administration of production, maintenance, personnel and financial; besides this consulting, auditing, technical know-how, training, coordination and integration of units in the company, will also be important. Not to mention the need for participation in the development of new products and processes, participation in the project of the product and the factory, and acting in areas such as marketing, finances, planning, maintenance, operation, materials, quality and logistics.

The Engineer profile

According to what was published in Revista Educação [5], by specialists in recruitment and selection (the well-known headhunters), initiative, flexibility, courage to assume risks, capacity to generate results, determination, ambition, ability to work and lead teams, and disposition to compete, are personal and professionals characteristics that are worth gold anywhere in the world. In fact, globalized companies are in search of employees that can act in multiple roles, and not the typical segmented specialists of the past anymore. According to them schools are not doing anything, or very a little, to prepare this kind of professional for the future.

So, to satisfy these demands, and based on the contacts that we have with several of our clients (it is worth reminding that society as a whole is understood a client), we consider that the engineers should have the profile and formation that will now be described, according to each type of performance. The systemic engineer, who is committed with results, needs a global vision, preparation to deal and define problems, capacity to look for solutions without necessarily being able to solve them, solid knowledge of processes, ability in relationship and team work, financial knowledge, logical reasoning and managerial attitude.

The design engineer, who is committed with the solution of problems, he needs preparation to solve problems, good technical and scientific formation, specialization, team work, notions of borders, trade off notions, interdisciplinary relationship

It is evident that these characteristics will be common to both, but they are mainly related to cultural, intellectuals and personal aspects.

The schools of engineering in this context

The Schools of Engineering have two essential attributions, which are the formation of professionals to adequate the reality of the country, and the search, development and adaptation of new knowledge, with the objective of disseminating them, giving support to a continuous evolution and improvement in the quality of life.

A question comes spontaneously inquiring if these missions are being executed. We cannot forget that, in the industry, the financial and the commercial areas and engineering, are, undoubtedly, the three main knowledge forces. Stephen H. Rhinesmith [3] is categorical when affirming that "if we looked at the methods of social science and adults' education that we are using today to help people to deal with these scientific changes in acceleration, we will see that we are still bound to a lot of ideas and methods which were popular in the years 50's and 60's."

The engineer's responsibility today, in a global organization, is not just limited to strategies and commercial and manufacture tactics, to reach the organizational objectives. More than ever, the global engineers need to think of the organizations systemically, and with no limits, as cultures that have to adapt and modify themselves to survive. To be a global engineer, it is not necessary to be a systems theoretical, but it is necessary to be capable of thinking in a systemic, but even so, in an open, creative and intuitively way. According to Barlett and Ghostal [4], globalization deals with the modification of organizations, but first, it deals with open minded people. It is impossible to develop a competitive, fluent global organization, with people who are narrow- minded and psychologically unstructured.

Schools of Engineering need a challenge to reach this transformation, and they have to learn to deal with the organizations and a new vision of the world, so that they may be unlimited, and not closed systems. Furthermore they need a new behavior, that emphasizes an opening to changes: think the

inconceivable and be prepared to take advantage of surprise. They should think of the development of methods which help others to understand, and train these new behaviors, not to duplicate our own learning, but to increase the process of generation of new forces and help in shaping the future.

Finally, structure organizations, systems and relationships should be re-defined so as to be able to survive and be successful in all situations.

How FEI deals with this challenge

FEI was founded 51 years ago by a Jesuit Priest, Father Sabóia de Medeiros. At that time, he had an inspiration ad an objective, which was the creation of an engineering course to prepare qualified professionals to help the industry that would emerge in the after-war period, as an answer to a new economic model that the country needed. He understood that an engineer with a special profile, would have to be formed, as different from the traditional ones and with a focus on the different activities of the industry: he used therefore Industrial Engineering as a name for the School.

With a spectacular vision for that time, he had the conviction that the mission of a School of Engineering was not only restricted to supply qualified engineers, ready and adapted for the labor market. He believed that, it is also part of its mission, research as a support to the industrial development, recycling and modernization of the industrial community's technical and scientific knowledge. On giving continuity to his ideals, two Institutes were created, with specific objectives to assist these activities. IPEI was created with the purpose of studying, projecting and researching industrial problems, and to give support to the development and technological modernization. IECAT was created with the purpose of disseminating knowledge, recycling and specialization through extra-curricular courses, to back up and assist the productive communities needs.

As an indirect reward, the school benefited with the constant and strict relationship with Enterprise, Society and School, where the problems and the tendencies of the managerial activities can continuously and precisely be detected. Based on these verifications, in our continuous modernization and knowledge, and in the effective economic and managerial structures, we can characterize the profile of an engineer of usefulness can be characterized with improvements in curricular courses, according to current legislation, quite easily.

It can be noticed that the mission of FEI was traced right from its foundation and all efforts are set to keep it always a modern course, to form engineers useful to the society.

To face these challenges, the efforts were divided in two great areas, that is to say, the didactic-pedagogical and technical-scientific. In the didactic-pedagogical area, the objective was to develop, in the students, the habit of study, organization of time, disciplines, reasoning and the increase of the efficiency in study. For this, the adaptation of methods have been looked upon considering the youth's culture, the improvement of the quality of the students' life, and continuous evaluation, conceptual focus of the disciplines, the use of the computer as a support tool, theoretical and practical classes in laboratories. The importance of lab classes may be verified on considering that there are 73 laboratories with a built area of 9.100 m^2. In the technical-scientific area it is important the future professional training to keep up with technological, economical and social evolution. For this it has been given a strong theoretical basis and a practical, solid humanistic formation, knowledge of advanced technologies to the students and efforts have been done to develop their creativity and initiative.

Several agreements and exchanges with national and international universities, research centers and leading technological companies have been made to keep the school constantly up-dated. The constant recycling of professors has been accomplished through seminars, workshops, and courses of specialization and graduate programs.

Changes in the engineering curriculum

Once the premises of the interaction between the institution and the community have been established, we will approach some changes in the engineering curriculum that we think are vital to reach our purposes.

It is evident that the current curriculum is based on a taylorist formation, where specialists are expected to be necessary in certain branches of the engineering. In this globalization era, what society expects, even from trainees, is an emphasis on creativity, general vision and team work capacity. Specialization comes later, through proper training in company, extension courses or graduate programs. However, in spite of this we continue to spend years of work trying to form specialists in a certain engineering branch, but without success, since the load on this "pseudo-specialization" is exaggerated in extension, but not in depth. With this they neither receive an integrated vision of their own branch, nor the one of the engineer's role in society. It is our opinion that this lack of vision is the main cause of escape from engineering courses, which, in some cases, reaches more that 50%.

Since we cannot give up the basic formation in sciences and mathematics, indispensable both in the reductionist and the systemic sight, two solutions seem immediate to diminish the problem. At first, the introduction, right from the beginning, of integrating disciplines driven to tangible results for engineering employment. This would be carried out along the first two years.

During the third year emphasis should be given to disciplines linked to production engineering, especially manufacturing processes, and the fourth year, should be dedicated to deepen the basic knowledge in each specific area, such as mechanics,

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electronics, chemical, civil, etc. engineering. Finally, in the fifth year, there should be specialization in specific fields such as automotive, project or production mechanics.

It should be emphasized the creation of, and the search for, knowledge along the course, and it should be introduced a discipline for scientific methodology. the other disciplines should motivate research, from a simple bibliographical research (subject revision) up to experimental research, within the degree of the student's competence. This is an important aspect to consider. There is a tendency to exaggerate, in engineering teaching, either considering the student an irresponsible adolescent or an uninterested adult, forgetting to think on how he can really be motivated. This leads to extreme attitudes, dividing schools in two group, one which thinks only of students in terms of "what you pay is what you get", and the others in terms of permanence in the course, in the sense that "the longer it takes, the harder it is and, for this reason, the better the school". The conceptual vision used in Operation Systems should be the right attitude with reality, where the student should be considered sometimes as a product that the school offers to the labor market, and other times as a customer, that deserves to be tutored, to help him find the way to build knowledge more easily. This is necessary for his profession and for himself, so that he may feel like a human being, that receives attention of his piers and masters.

The student, upon entering an engineering course, has already enough knowledge of life, and foundations, received in secondary school, that allow him to solve simple problems of engineering, like building a bicycle, a small house, or other, so as to stimulate his interest. So, under the coordination of a professor of industrial engineering, specialist in viability studies and projects management, a discipline like "Basic Project of engineering" should be inserted in the curriculum. A group of students would define a simple product and they would go through the project up to its implementation, using concepts of math's, physics, chemistry, etc.; they would already feel like an engineer's participating in a real life project. On doing this along a year, the student would begin to realize the reason of the curriculum, and why and how geometry, properties of the materials, formulas of mechanics and thermology are used, just to mention a few disciplines.

It is said, that the best way to define a research is to have a clear vision of the point where one intends to get to, and this is also true when applied to teaching. This certainly becomes more obvious when, as it happens today, students first have to define their area of specialization. The creation of an interlude, in the third year where a general vision of the opportunities in engineering would be given, would direct the students to the last years, convinced of the they want to do and therefore motivated to study.

The students, intuitively, already know this, when they struggle for stage at the beginning and at the end of the course. Will this be because of bare necessity or to fill a possible vacancy in the market after their graduation? Or because they don't find in our traditional courses answers to their doubts and anguishes on what an engineer really does? Or what does society expect from him? What will he do when he has to run his own business? Will he be successful in another activity, not necessarily linked to engineering, but where the knowledge acquired will be extremely useful?

Curricula are easy to be changed overnight. What is necessary, in the first place, is the consent of the change need. Starting from this the faculty and student, together with the community and former-students, turned to the scenery that the globalization is showing us, to discuss thoroughly the subject and eventually abandon the old paradigm.

FEI is deeply concerned with the situations that have been described above. With the support received from the directive and administrative body, the collaboration of professors, interested in the change of the current paradigm in the teaching of engineering, FEI is preparing a reformulation of curricula and is adapting a pedagogical plan that supplies the faculty with the tools and the vision for the work which necessary to restructure teaching.

We expect, in a short time, to have the answers that society is asking for and, therefore we believe that engineering, properly revised in terms of teaching and centered on a strong and deep social and technical sensibility, may be come indispensable in a world of exponential technological progress, but even so immersed in absolute social perplexity.

Final considerations

It is time now we begin to rethink engineering in a wide, open way and with a modern vision, with the participation of the several class entities, city councils, society, ministry of the education and engineering schools.

Is it possible for schools to form an engineer who is equally qualified to act as a researcher, planner and systemic? Or should the schools specialize and define the engineer type that they will form? As Salvagni [7] suggests, in the past, an engineer's diploma was a permanent certificate for professional competence. An engineer that retired, thirty years ago, probably never needed, in all his professional life, anything more than that he learned at school. Today, technological evolution runs very fast and the obsolescence faster still. However, an engineer that graduated thirty years ago and did nothing to get updated, still has the same attributions, responsibilities and professional rights granted by the professional councils, as those of an engineer that has just finished a specialization course.

Finally, we consider it is very important that a precise evaluation of the youths' growing indifference for engineer's profession be done. The labor market has been charged for this, still we should put the question if the courses themselves and the very engineer profession as it is, divorced from reality, are not the real responsible ones for this situation!

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